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Memorandum

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From: Scott Helm, P.E.
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Date: June 22, 2007

Subject: NH-F 8-4(16)78
Townsend – South
CN: 01420
Geotechnical Engineering – Alignment (Activity 464) Report

The Geotechnical Section has completed its analysis for alignment and minor structure features for the subject project.

Location

The project is located on US 287 in Broadwater County, in Township 6 North, Range 2 East, Sections 5, 6, 8, 16, 17, 21, 27, 28, and 34 and Township 5 North, Range 2 East, Sections 3 and 10. The project begins at RP 78.1±, near the southern Townsend city limits, and extends southerly 13.21 kilometers to RP 86.1±.

Intent

It is our understanding that the intent of this project is to reconstruct this portion of US 287 to current road design standards. The work will include a horizontal alignment shift to the east of the current PTW throughout most of the project. Minor changes to the vertical alignment will be made to address drainage facilities, structures, and to improve stopping sight distances as necessary. The design speed for this project is 110 km/h. Several passing lanes are also proposed for this project.

Synopsis

This Report provides the results of subsurface exploration and Geotechnical engineering studies and Geotechnical recommendations for the design and construction of the project alignment and minor structure features. A separate report will be provided for the bridge structure proposed for this project. This Report includes brief descriptions of the areal geology and our field investigation. Also included are recommendations for embankment foundations (standard and shot rock based); embankment foundation settlement

estimates; culvert foundations; embankment and cut slope ratios; subgrade treatment; and moisture sensitive soils. Appropriate Special Provisions and Details are included.

Areal Geology

The area is mapped as alluvium and Greyson Shale. Alluvium (Qa) is mainly stream laid sands and gravels. The sands and gravels are poorly graded and well rounded within the Missouri River floodplain and well graded and poorly rounded in areas outside the floodplain. Greyson Shale is composed mainly of green-gray siltite and fine quartzite. Based on the geologic mapping in this area, the alluvium ranges from 60 to 120 meters in depth throughout the project area. As anticipated prior to drilling, formation was not encountered during our investigation. Surficial soils have been mapped throughout the project corridor as silts, sandy silts, and clays.

Field Investigation

From January 6 to June 22, 2006, the MDT Field Investigation Unit advanced 73 borings throughout the project. Drilling was conducted in 3 separate phases (phases I, II, and III). One boring was conducted for a minor cut section and the remaining borings were drilled to determine proposed embankment and/or culvert foundation characteristics.

The project was arbitrarily broken into 3 sections, based on distance along the project corridor, field observations of soils and groundwater conditions, and preliminary laboratory test and analysis data. The three sections are as follows: Section 1(Northern Section): Beginning Of Project (BOP) to Station 70+00; Section 2 (Middle Section): stations 70+00 to 114+00; Section 3 (Southern Section): station 114+00 to End Of Project (EOP).

Section 1 Observations:

Section 1 has 18 borings within the corridor, with depths ranging from 2.7 to 8.1 meters.

Soils Encountered:

The following soil types were encountered during the subsurface investigation:

- Silts with varying amounts of sand and gravel.
- Sands with varying amounts of silt and gravel.
- Gravels with varying amounts of sand and silt.
- Clayey Sands and Gravels (encountered at depth at the Deep Creek structure).
- Lean, Fat, and Silty Clays.
- Elastic Silts.

Soils Class Range:

The soils encountered fell within the following AASHTO Soils Classification ranges:

- A-1-a to A-7-6.

The majority of shallow (<6m) soils are composed of A-4, A-6, and A-7 soils.

Densities/Consistencies:
The soils encountered exhibited the following density/consistency ranges:
- Cohesionless material densities range from very loose to very dense but are primarily in the loose to medium dense categories.
- Cohesive material consistencies range from very soft to medium stiff but are primarily in the very soft to soft categories.

Groundwater Levels:
- Groundwater levels ranged from 0.8 to 5.2m, while drilling. Groundwater was encountered in all 18 borings. The northern portion of Section 1 exhibits surficial alkali deposits indicative of shallow groundwater levels that undergo frequent fluctuations. Some of this may be attributable to the seasonal use of the Montana Ditch to convey irrigation water. It is anticipated that groundwater levels will fluctuate seasonally.

General Soil Profile:
The general soil stratigraphy encountered is as follows:
- 0.9 to 6.2m of cohesive/fine grained material overlying denser sands and gravels.

Liquidity Indices:
Experience has shown that operation of construction equipment becomes inefficient when the Liquidity Index (LI) exceeds approximately 0.35 and may become unworkable when values exceeding 0.5 are indicated.
- LI's range from **0.0** to **1.78**.
- Of the values observed, 31 values over 0.3 were recorded, **indicating that potentially problematic soils are prevalent in this portion of the project.**

Section 2 Observations:
Section 2 has 37 borings within the corridor, with depths ranging from 0.9 to 9.6 meters.

Soils Encountered:
The following soil types were encountered during the subsurface investigation:
- Silts with varying amounts of sand and gravel.
- Sands with varying amounts of silt and gravel.
- Gravels with varying amounts of sand and silt.
- Clayey Gravels.
- Lean, Fat, and Silty Clays.
- Elastic Silts.

Soils Class Range:
The soils encountered fell within the following AASHTO Soils Classification ranges:
- A-1-a to A-7-6.

The majority of shallow (<6m) soils are A-4 and A-7.
Densities/Consistencies:
The soils encountered exhibited the following density/consistency ranges:
- Cohesionless material densities range from very loose to very dense but are primarily in the very loose **and** medium dense categories.
- Cohesive material consistencies range from very soft to very stiff but are primarily in the very soft to soft categories.

Groundwater Levels:
- Groundwater levels ranged from 0.0 to 5.8m, while drilling. Groundwater was encountered in 36 of the 37 borings. No groundwater was encountered in boring 1420-033 (Station 113+22). It is anticipated that groundwater levels will fluctuate seasonally.

General Soil Profile:
The general soil stratigraphy encountered is as follows:
- 0.6 to 4.3m of cohesive/fine grained material overlying denser sands and gravels.

Liquidity Indices:
- LI's range from **0.0** to **6.35**.
- Of the values observed, 23 values over 0.3 and 19 values over 0.5 were recorded, **indicating that potentially problematic soils are prevalent in this portion of the project.** The area from approximately station 87+00 to 98+00 will be especially problematic with respect to the surficial soils and due to standing water/ponds. This area also contains soils that are either organic or contain a significant amount of organic material within the soil mass structure (i.e. rotted wood, roots, cattails, reeds, etc.)

Section 3 Observations:
Section 3 has 18 borings within the corridor, with depths ranging from 1.5 to 9.6 meters.

Soils Encountered:
The following soil types were encountered during the subsurface investigation:
- Silts with varying amounts of sand and gravel.
- Sands with varying amounts of silt and gravel.
- Gravels with varying amounts of sand and silt.
- Silty, Clayey Sands.
- Lean and Fat Clays with varying amounts of sand.

- Elastic Silt.

Clays and silts/elastic silts constitute the vast majority of soils encountered in Section 3.

Soils Class Range:
The soils encountered fell within the following AASHTO Soils Classification ranges:

- A-1-a to A-7-6

The majority of shallow (<6m) soils are A-7.

Densities/Consistencies:
The soils encountered exhibited the following density/consistency ranges:

- Cohesionless material densities range from very loose to very dense but are primarily in the loose category.
- Cohesive material consistencies range from very soft to very stiff but are primarily in the medium stiff category.

Groundwater Levels:

- Groundwater levels ranged from 3.0 to 6.1m, while drilling. Groundwater was encountered in 2 of the 18 borings, 1420-002 (Sta. 115+25) and 1420-032 (Sta. 116+18). Groundwater was not encountered in any of the remaining borings at the time of drilling. However, it is anticipated that groundwater levels will fluctuate seasonally.

General Soil Profile:
The general soil stratigraphy encountered is as follows:

- 1.8 to 6.1m of cohesive/fine grained material overlying denser sands and gravels.

Liquidity Indices:

- LI's range from **0.0** to **1.45.**
- Of the values observed, 10 values over 0.3 recorded, **indicating that potentially problematic soils are present in this portion of the project.** However, the higher LI values were only encountered in very isolated areas within this section of the project.

Boring logs for this project have been distributed and are attached.

Design Recommendations
Embankment Foundations
Proposed embankment foundation areas were evaluated for support characteristics and constructability throughout the project. The District Soil Survey, Geotechnical subsurface investigation results, and visual observation of the foundation areas were used to develop our recommendations.

Two types of embankment foundation treatment are proposed for the project, Standard (Embankment Foundation Treatment hereinafter) and Rock Fill Embankment Foundation Treatment (Modified Embankment Foundation Treatment hereinafter). Embankment Foundation Treatment consists of High Survivability Stabilization Geotextile and Special Borrow placed prior to embankment construction. Modified Embankment Foundation Treatment consists of 1.2 meters of Rock Fill, 150mm of Special Borrow (as cushion material to prevent geotextile installation damage), High Survivability Separation Geotextile, and Special Borrow placed up to the subgrade elevation.

Embankment Foundation Treatment is recommended for the following areas due to the prevalence of soils with poor support characteristics, shallow groundwater levels, high liquidity indices, and other factors indicative of unsuitable near surface embankment foundation support:

- 37+30 to 45+00, Left
- 71+00 to 78+50, Left
- 81+00 to 82+00, Left
- 86+60 to 88+10, Left

For all Embankment Foundation Treatment areas, begin the treatment at the bottom of the PTW slope and extend perpendicular to within one meter of the toe of the proposed embankment. Extend geotextile up the existing slope one meter as measured on the slope face. Bench existing slopes in accordance with Section 203.03.2 C of the Standard Specifications.

We recommend Modified Embankment Foundation Treatment in the following areas due to the prevalence soils with poor support characteristics, high organic contents, surface or standing water/ponds, high liquidity indices, and other factors indicative of unsuitable embankment foundation support.

- 88+10 to 99+00, Left
- 96+00 to 99+00, Right

For all Modified Embankment Foundation Treatment areas, begin by placing 1.2 meters of Rock Fill at the bottom of the PTW slope and extend perpendicular to the toe of the proposed embankment. Place 150mm of Special Borrow, as cushion material, over the Rock Fill. Place geotextile, starting one meter up the existing slope (as measured on the slope face) and extend perpendicular to with 0.5 meters of the proposed embankment slope. Finally, place Special Borrow up to the subgrade elevation. Special Provisions for Embankment Foundation Treatment, Modified Embankment Foundation Treatment, Special Borrow, and Rock Fill are attached.

Embankment Foundation Settlement Estimates

Proposed embankment foundation areas were evaluated for total settlement. Based on our analyses of representative embankments, approximate foundation settlement range estimates are shown below.

- Section 1: 1 to 6 inches
- Section 2: 1/2 to 7 inches
- Section 3: 1/2 to 4 inches

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The estimated time for 90% consolidation of the embankment materials ranges from instantaneous (occurring over the course of construction) to as much as 3+ years, with most of the settlement occurring within a year or less. **It should be noted that all of the estimated settlement could be realized as differential settlement between the existing PTW and proposed embankments.** This differential settlement may cause distress in the paving section between the portion of the existing embankment and the newly constructed embankment. This distress could cause excessive longitudinal and transverse cracking leading to premature pavement failure. The estimated settlement will also affect proposed culverts on the project

Because of the time required for the majority of consolidation to occur and the potential for large differential settlement, we strongly recommend that the proposed embankments be constructed up to the subgrade elevation and then be allowed to remain for a minimum of six months to allow the maximum amount of settlement to occur prior to construction to the final subgrade elevation. In addition, we strongly recommend a settlement monitoring program to evaluate (immediately after initial construction and during embankment settlement time) to determine when the rate of settlement has slowed to the point that any remaining settlement will not be detrimental to the stability of the paving section.

This monitoring program is normally accomplished by the use of settlement plates or other Geotechnical instrumentation. However, in the interest of reducing overall project costs, an alternative consisting of simple surveys of embankment top elevations could be done after initial embankment construction, to collect the data necessary to evaluate settlement rates.

Proposed initial survey requirements would be to monitor each of the points twice weekly for the first month, weekly the following two months, and monthly thereafter until either six months has passed or it has been determined that the majority of settlement has occurred.

Embankment Slopes

Proposed embankment slope ratios are a maximum of 4H:1V. In our opinion, the proposed embankment slope ratios are adequate for the project. If embankment design slope ratios require adjustment either in the design or construction phases of the project, the Geotechnical Section should be contacted to review the changes.

Culvert Foundation Treatment Areas

Culvert Foundation Treatment, consisting of 0.6m of subexcavation, geotextile, and foundation material, is recommended at the following locations:

Station	Station
29+34	65+60
34+60	74+25.2
37+20.8	74+30
38+66.4	77+17.6
44+53.6	84+48
44+60	86+80
52+19.5	97+40
55+27.2	110+83.5
60+73.2	147+20
65+28.3	149+60

A Special Provision for Culvert Foundation Treatment is attached.

Cut Slopes

The maximum proposed cut slope ratios are 4H:1V or flatter. In our opinion, the cut slope ratios are adequate for the project. If slope ratios require adjustment either in the design or construction phases of the project, the Geotechnical Section should be contacted to review the changes. All project grading materials from proposed cut excavation areas are expected to be suitable for use elsewhere on the project with proper moisture and compaction control.

Subgrade Treatment

Throughout the project, the proposed surfacing section consists of 120mm of Plant Mix Surfacing, 280mm of Crushed Aggregate Course, and 600mm of Special Borrow. The surfacing section is based on a design R-value of 20.

Field observations of the existing paving section do not indicate any substantial pavement distress due to poor subgrade conditions in the PTW. However, drilling results indicate some isolated areas that could be treated through the use of subexcavation of the PTW.

Additionally, the original alignment (constructed in 1939) was built predominantly from side borrow materials (silts and clays). This may indicate the need for some quantity of subexcavation to be included within the project for bidding purposes in the event spot subgrade problem areas are encountered.

However, the recently completed VA study done for the project included a recommendation (Creative Idea No: 2) to pulverize the existing plant mix surfacing (PMS) and blend it with the underlying base course, in lieu of excavating the PTW and replacing the excavated material with Special Borrow. This would be done in areas where the top of the existing PMS is below the top of the proposed Special Borrow. The design team agreed to incorporate this idea into the project by Special Provision.

Additionally the plans and cross sections indicate that either the VA study recommendation or the 600mm of Special Borrow will be utilized to construct the typical section throughout the entire project length.

No specific subgrade treatment recommendations will be made with this report based on:

- Subexcavation areas on the project would be limited and potential material quantities are minor
- The incorporation of the VA study recommendation
- The proposed use of typical sections with 600mm of Special Borrow
- Special Borrow and geotextile are included in the contract through other bid items

Bridge End Backfill

Bridge End Backfill, consisting of Crushed Aggregate Course, will be utilized at the Deep Creek structure. A Bridge End Backfill Special Provision is attached.

Moisture Sensitive Soils

Based on the information from the Geotechnical subsurface investigation and the District Soil Survey, moisture sensitive soils are prevalent throughout the project. Small increases in moisture content are detrimental to the strength of these soils, possibly resulting in construction difficulties. A Moisture Sensitive Soils Special Provision is attached.

Miscellaneous

On the plan and profile sheets, the District Soil Survey holes should show the hole number in the plan view. The Geotechnical Section borings should be labeled with the proper boring identifier (i.e. CL 1420-15) in the plan view.

Professional judgments and recommendations are presented in this report. They are based partly on evaluation of the technical information gathered, partly on historical reports and

partly on the Geotechnical Section's general experience with subsurface conditions in the area. The Geotechnical Section does not guarantee the performance of the project in any respect other than that the engineering work and the judgment rendered meet the standards and care of the profession. It should be noted that the borings may not represent potentially unfavorable subsurface conditions between borings. If, during construction, soil conditions are encountered that vary from those discussed in this report or historical reports, or if design loads and/or configurations change, the Geotechnical Section should be notified immediately in order that it may evaluate effects, if any, on foundation performance. The recommendations presented in this report are applicable only to this specific site. These data are not to be used for other purposes.

Questions regarding this matter may be directed to Patrick McCann, MDT Geotechnical Section @ (406) 444-6277 (pmccann@mt.gov), or Scott Helm @ (406) 444-6279 (shelm@mt.gov).

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Materials File
Geotechnical File

Attachments: Bridge End Backfill Special Provision
Culvert Foundation Treatment Special Provision
Embankment Foundation Treatment Special Provision
Modified Embankment Foundation Treatment Special Provision
Moisture Sensitive Soils Special Provision
Rock Fill Special Provision
Special Borrow Special Provision
Boring Logs
Boring Locations Strip Maps
Laboratory Test Summary

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